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Discovery of the Jaw Apparatus of the Upper Volgian Ammonite *Kachpurites fulgens* (Craspeditidae)

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Abstract—The jaw apparatus of the genus *Kachpurites* (Ammonoidea, Craspeditidae), consisting of a pair of aptychi and a beak-shaped upper jaw is described and figured for the first time. A new aptychus species *Praestriaptychus fulgens* sp. nov. is established. Aptychi of this species are elongated-triangular, weakly ribbed, with a well-developed inner organic layer and a considerably thinner, often poorly preserved external calcite layer. Specimens of the type series were found in the body chamber of ammonites *Kachpurites fulgens* (Trautschold), from the Upper Jurassic (Upper Volgian) *Kachpurites fulgens* Zone of Moscow and the Moscow Region.

Keywords: Ammonoidea, Craspeditidae, aptychi, jaw apparatus, Upper Volgian, Russia

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INTRODUCTION

Aptychi are jaw elements of ammonites, rarely found in the Jurassic of the Russian Platform. Aptychi *Laevaptychus* associated with the ammonite family Aspidoceratidae are an exception to this general rule, as they are relatively frequently found in the Upper Kimmeridgian beds (Vischniakoff, 1875; Hantzpergue et al., 1998; Rogov, 2002a). Aptychi *Laevaptychus* have a thick external calcite layer, which explains their good state of preservation. Other aptychi are much less commonly preserved. Aptychi *Praestriaptychus*, associated with most ammonites of the superfamily Perisphinctoidea, a particularly rare. These are relatively thin aptychi with a weakly developed calcite layer (Engeser and Keupp, 2002). In aptychi of the Upper Jurassic Boreal perisphinctids, this initially thin layer is additionally reduced (Rogov and Mikhailova, 2006). Apparently, it was the thin calcite layer of *Praestriaptychus* that made their occurrences so rare.

The ammonite family Craspeditidae Spath, 1924 was abundantly represented at the Jurassic–Cretaceous boundary in the Boreal and Subboreal realms (Mitta, 2010). Despite that, aptychi of ammonites of this family have been only mentioned twice in the literature. The first record mentioned aptychi *Praestriaptychus*, belonging to ammonites of the family Craspeditidae, but with no description or illustration (Engeser and Keupp, 2002). In the second record, the aptychus of a craspeditid ammonite was figured, but not properly described (Rogov and Mikhailova, 2006).

Ammonite aptychi from the Volgian Stage of the Russian Platform were described only twice (Rogov 2004b; Rogov and Mikhailova, 2006). Only in one case was an aptychus found in an ammonite body chamber, originally identified as *Craspedites okensis* (Rogov and Mikhailova, 2006), although it is quite possible that the ammonite belonged to the genus *Kachpurites* (M.A. Rogov, pers. comm.). In the earlier, Middle Jurassic (Callovian) beds, aptychi *Praestriaptychus* were found both separately from ammonites (Rogov, 2004a), and in the body chambers of perisphinctids, i.e., aptychi *Praestriaptychus koenigi* in the body chamber of *Proplanulites* koenigi (Rogov and Gulyaev, 2003) and *Praestriaptychus* sp. in the body chamber of *Elatmites* sp. (Mitta and Keupp, 2007). Aptychi were also found in the Lower Callovian and Upper Bathonian, together with the ammonites *Kepplerites* and *Sigaloceras* (Mitta, 2009; Nikitin, 1884; Keupp and Mitta, 2013).

The upper jaws of Jurassic ammonites from the Russian Platform have only been described from the Lower Callovian (Mitta and Keupp, 2004, 2007; Keupp and Mitta, 2013). They are found in nodules in association with shells of ammonites of the families Cardioceratidae, Kosmoceratidae, and Perisphinctidae, and also in association with the lower jaw (aptychi) in the body chamber of ammonites of the genus *Kepplerites*. No upper jaws have been previously found or described from the Volgian of the Russian Platform.

MATERIAL

Isolated and paired aptychi and an ammonite upper jaw were found in the body chambers of the ammonite *Kachpurites fulgens* (Trautschold) (family Craspeditidae). Ammonites were collected by the present authors in 2012 in a quarry of the Ramenskii Enrichment Mining Factory, in the vicinity of the vil-

lage of Eganovo (Ramenki District, Moscow Region), 50 km southeast of Moscow (Fig. 1). The quarry mines Late Jurassic and early Cretaceous sands, while the Upper Volgian clay is exposed by drainage trenches. Another pair of aptychi was found in the body chamber of *K. fulgens* in the summer of the same year in a small section in Moscow, on the bank of the Moscow River (Karamyshevskaya Embankment) (Fig. 1). This specimen (no. 116/3) was found and donated by amateur paleontologist Ruslan Shirokov.

All specimens come from the *Kachpurites fulgens* Zone of the Upper Volgian Substage and were found in entire and incompletely preserved shells of *K. fulgens*. In most cases, these are shells of microconchs or young specimens, but one aptychus was found in a supposed macroconch shell. Due to the absence of terminal aperture modifications in representatives of the family Craspeditidae and incomplete preservation of many shells, the identification needs to be based exclusively on the shell size.

Specimens studied show variously preserved jaw apparatuses. For instance, specimen nos. 116/1 and 116/5 represented isolated aptychus valves. Specimen no. 116/1 (Pl. 2, fig. 1) is an aptychus with a well-preserved inner and thin fragmentary outer layer. Except a small portion in the central region, the aptychus is completely preserved. It is located in the middle part of the body chamber of a microconch of *K. fulgens*. The shell diameter of the ammonite shell is 39 mm, the aperture is 11.5 mm high, the width is 10 mm. The parameters of the aptychus are given below, in the species description. The aptychus length almost coincides with the apertural height. The aptychus surface possesses smoothened, but distinct ribs and growth lines, and the external margin is somewhat thickened. The outer calcite layer is very thin, light brown, preserved as small fragments over most of the surface area of the aptychus. Specimen no. 116/5 (Pl. 2, fig. 5) is represented by a large aptychus in a fragment of the body chamber of a ribbed (?) macroconch. The complete shell diameter is unknown, whereas the length of the preserved fragment is 65 mm and the maximum whorl height is 16 mm. Singular coarse ribs are preserved on the shell surface on the side opposite of the aptychus. The surface of the inner organic layer of the aptychus is weakly ribbed, with noticeable, but low ribs and growth lines. This layer is almost completely preserved, except a small region near the terminal margin of the aptychus. The outer calcite layer of the aptychus is preserved as small areas on the organic layer surface.

Specimens nos. 116/2 and 116/3 represent joined aptychi (complete ammonite lower jaws). For instance, specimen no. 116/2 (Pl. 2, fig. 4) is represented by paired aptychi occurring in the centre of the body chamber of *Kachpurites fulgens*. Only a fragment of the body chamber 30 cm long is preserved. The height of the body chamber at the point where the aptychi were found is 10 mm. The aptychi are fissured but are almost completely preserved. The inner organic layer is weakly ribbed, whereas the outer calcite layer is very thin, fragmentary, and appears to be partly dissolved. Apparently, the upper jaw is preserved essentially in the life position. The width of the lower jaw is 5.5 mm, whereas the parameters of the aptychus are given in the table below. Specimen no. 116/3 (Pl. 2, fig. 3), is a pair of aptychi with a well preserved outer calcite layer, located in the body chamber of a microconch. The ammonite diameter is 26 mm; the aperture is 9 mm high. The aptychi are tightly connected to each other, but are partly preserved; the apical regions are lost, and only the side with the terminal angles remains. The aptychi are apparently in the life jaw position. This specimen, unlike all other specimens, has a very well preserved calcite layer. Its surface shows smoothened ribbing. The color of the calcite layer of this specimen is considerably lighter than that of other aptychi described in this paper. Because this particular specimen was found separately from all other specimens (in a section on the Karamyshevskaya Embankment), the difference in preservation is apparently linked to taphonomic differences. In one case (specimen no. 116/4), an incomplete macroconch shell in the middle of the body chamber contained paired aptychi and an upper beak-shaped jaw fitted between them. The diameter of the ammonite containing the above jaw fragments, is 27 mm, the aperture height is 9 mm, and the width is 7 mm. Due to the poor state of preservation the aptychus length cannot be precisely measured, while the width is about 7 mm and the width of each aptychus is 4 mm. The aptychi are separated by the rock matrix filling the body chamber- one is on the outer side and another is on the inner side. The outer calcite layer of one of the aptychi is completely destroyed, while the inner organic layer is incompletely preserved. The second aptychus is visible from the side of the inner layer, which is largely not preserved. However, this aptychus has the outer calcite plate preserved, in which the convex side faces down. The internal side of the aptychus is almost entirely smooth. The upper jaw of *Kachpurites fulgens* (Fig. 2), even before having been extracted from the rock, was

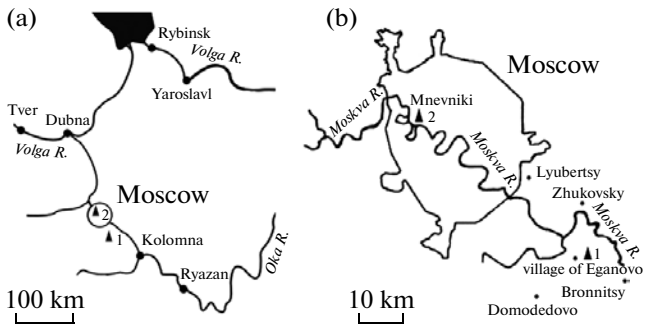


Fig. 1. Map showing localities. Explanations: (1) quarry of the Ramenskii Mining Enrichment Factory near the village of Eganovo (Ramenki District of the Moscow Region) (55°32′08.28″ N; 38°03′10.47″ E); (2) section on the bank of the Moscow River on the Karamyshevskaya Embankment, Moscow (55°46′4.12″ N; 37°28′4.67″ E).

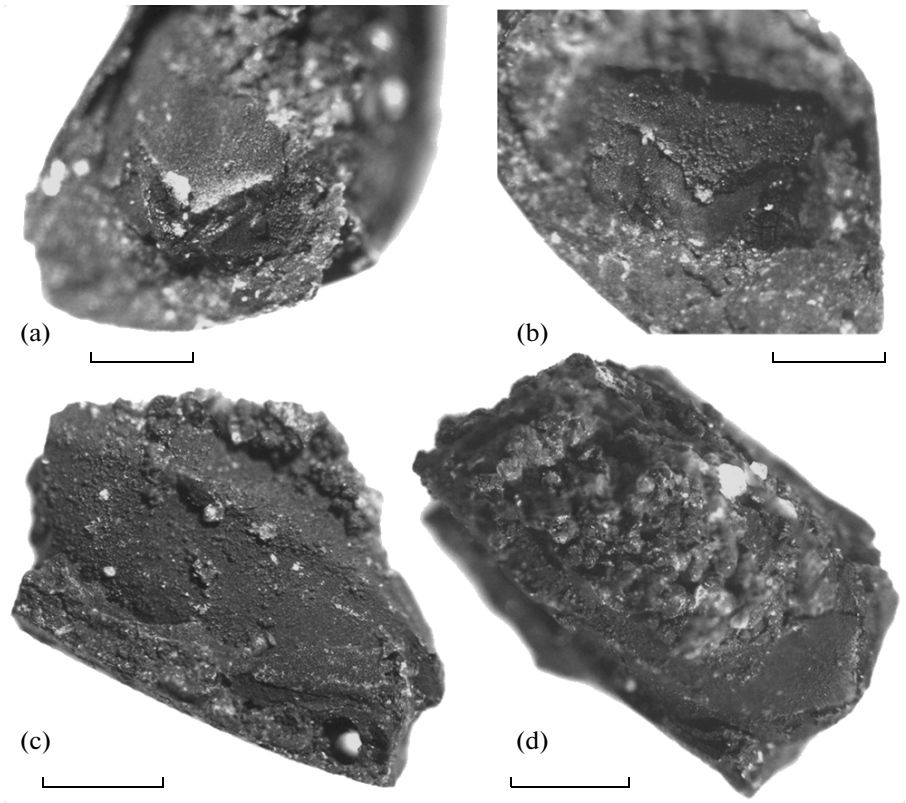


Fig. 2. The upper jaw of *Kachpurites fulgens*: (a) specimen no. 116/4-1, inner lamella, anterior view; (b) specimen no. 116/4-2, outer lamella, interior view; (c) specimen no. 116/4-1, inner lamella, lateral view; (d) specimen no. 116/4-1, inner lamella, upper (dorsal) view. The scale bar is 1 mm.

divided into two parts: the outer lamella (specimen no. 116/4-2) was separated from the inner lamella (specimen no. 116/4-1). Both fragments show a black coaly layer in the place of joining. (Figs. 3c, 3d). In the anterior region of the inner lamella there is a small curved projection (Fig. 3c), which apparently served as a support for the beak-like region of the outer lamella. The inner lamella has the following sizes: length 4 mm (apical end is broken off), the maximum height is 3 mm, and the maximum width is 2 mm. The outer lamella is housed in a small phosphatic nodule and is only visible from the place where it connects to the inner lamella. The width of the outer lamella is 2 mm, and its height is 1.8 mm. No specimen studied contained traces of radula, which probably were not preserved because the body chamber was filled with coarse-grained sand.

The aptychi and the upper jaw were studied using SEM at the Borissiak Paleontological Institute (PIN). All specimens described are housed in the Museum of Earth Science, Moscow State University, coll. no. 116.

DISCUSSION

The size of the aptychi studied for *Kachpurites fulgens* corresponds to the parameters of the apertural portion of the body chamber of the ammonites, in which they are found. The length of the aptychus of a supposed macroconch (Pl. 2, fig. 5) is similar to the height of the body chamber, suggesting similar proportions of the jaw apparatus in relation to the aperture of the shell both in micro- and macroconchs of *Kachpurites fulgens*. However, the ratio of the width of this aptychus to its length is higher than in other specimens described. It is suggested that the upper jaws of ammonites were much shorter than the lower jaws of the aptychus type (Kruta et al., 2011). An exception is the Early Callovian *Kepplerites*, where Keupp and Mitta (2013) recently described upper jaws as long as the aptychi. The length of the aptychi, found in association with the upper jaw of *K. fulgens* is about 7 mm, and the width of each is 4 mm. Taking into account the incompletely preserved posterior margin of the inner plate and separated outer plate of the upper jaw, its life length could have been 5 mm, which is only 0.71 of the length of the aptychi. Thus the length of the upper jaw of *K. fulgens* is slightly less than the length of its aptychi, but it cannot be considered to be much smaller than the size of the lower jaw.

It is noteworthy that the shape of the inner lamella of the upper jaw is very complex, with a noticeable central depression and paired shallow grooves on the shoulder separating the upper and lateral sides. Usually, lateral sides of the inner lamella of the upper jaw

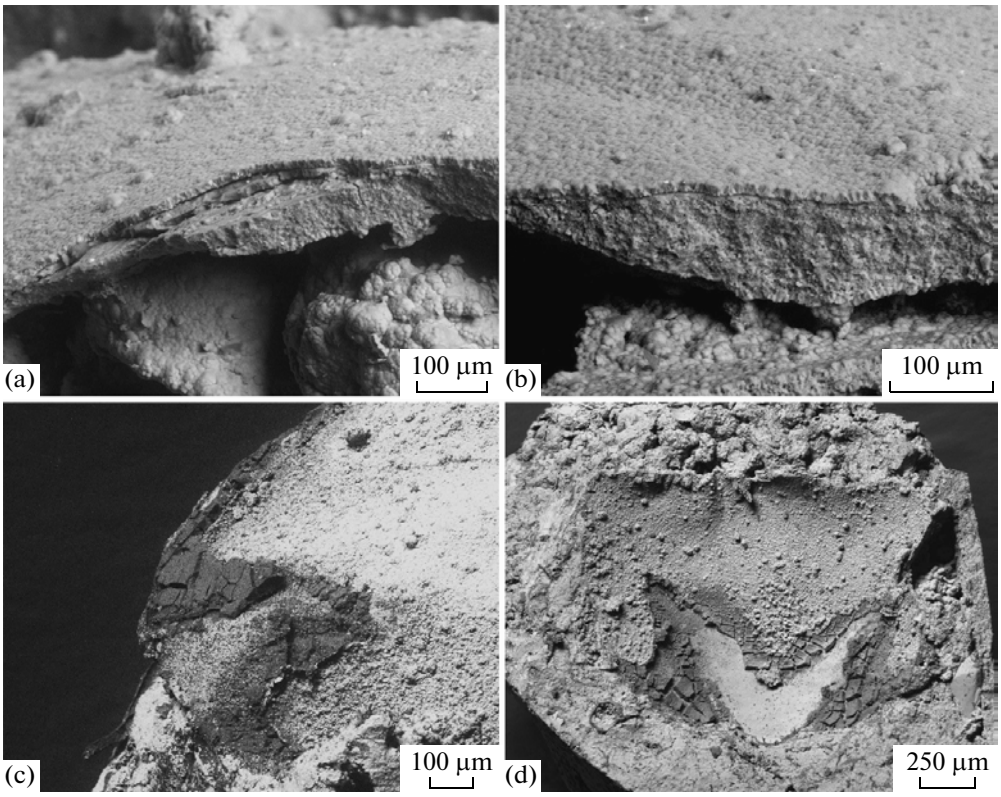


Fig. 3. Microstructure of the jaw apparatus of *Kachpurites fulgens*: (a, b) specimen no. 116/3, a broken surface of an aptychus showing a thin external calcite layer and considerably thicker organic layer; (c) inner lamella of the upper jaw of *Kachpurites fulgens* in place where it is connected with the outer lamella showing the carbonaceous layer in the place of plate meeting, and a small projection (left bottom) supporting the beak-like region of the outer lamella; (d) outer lamella of the upper jaw of *Kachpurites fulgens* in place where it connects to the inner lamella.

of ammonites are divergent, and the maximum distance between them is observed near the apical end of the jaw (see Tanabe and Landman, 2002, fig. 2; Mitta and Keupp, 2007, figs. 2, 3a; Keupp and Mitta, 2013, fig. 17). However, in *Kachpurites fulgens*, the maximum distance between the lateral projections of the plate is observed in its central region, and they are somewhat approximated apically (Fig. 2d).

It should be said that quite often the upper jaws of Jurassic and Cretaceous ammonites (belonging to Aptychophora) are found without the inner lamella (Doguzhaeva and Mikhailova, 2002; Mitta and Keupp, 2004; Keupp and Mitta, 2013). The ease, with which the upper jaw of *K. fulgens* was subdivided into two parts and the remains of a carbonaceous layer joining the external and inner lamellae suggest that the records of jaws lacking the inner lamella are the product of separation of two loosely connected elements in the jaw, rather than the reduction of the outer lamella (Keupp and Mitta, 2013). Apparently in ammonites with the aptychus type of jaws, the external and inner lamellas of the upper jaw were connected by a thin organic layer, which could easily be destroyed. This could have happened before the burial of the jaw in the sediment.

SYSTEMATIC PALEONTOLOGY

Genus *Praestriaptychus* Trauth, 1927

Praestriaptychus fulgens Mironenko, sp. nov.

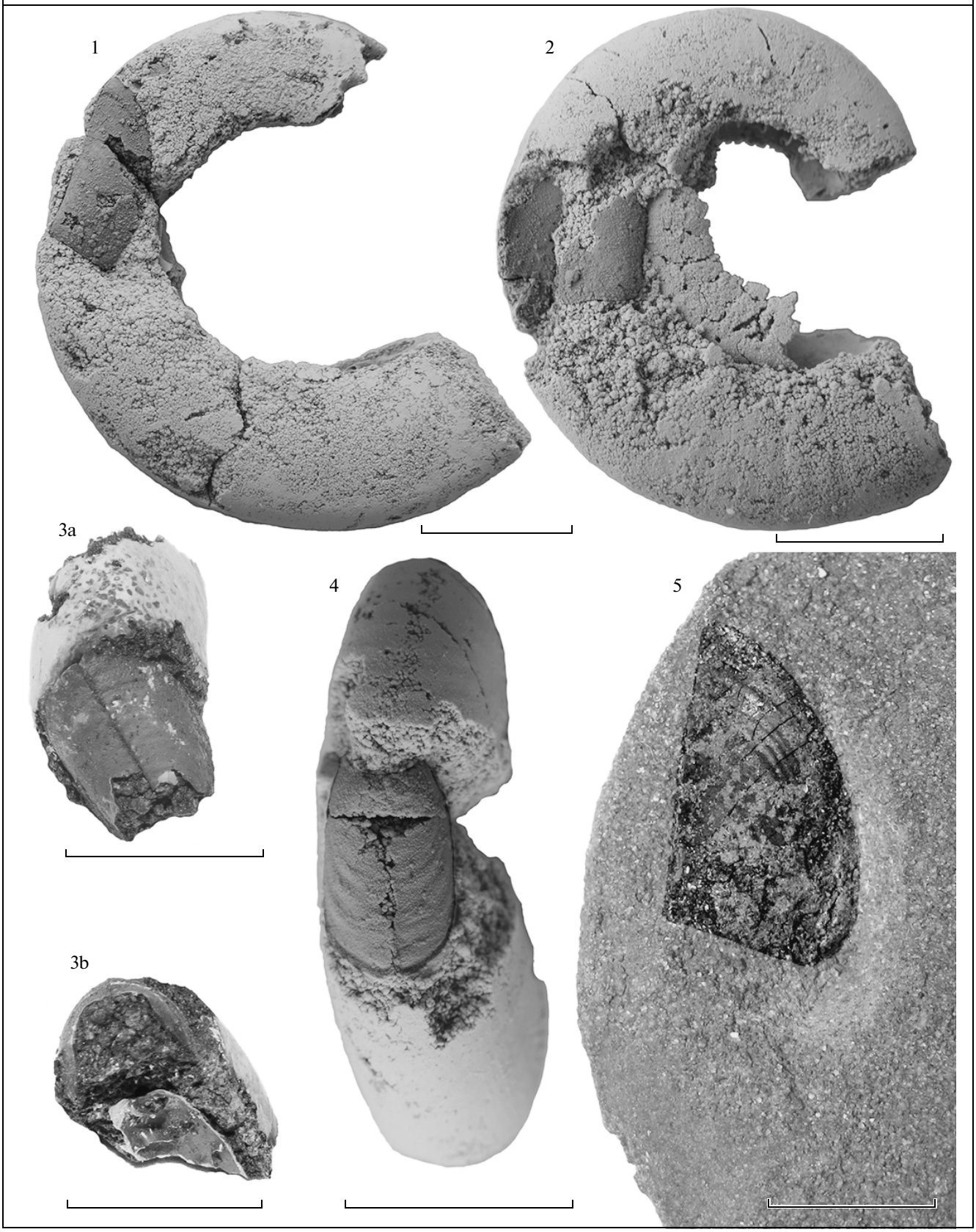
Plate 2, figs. 1–5

Etymology. From the ammonite name *Kachpurites fulgens* (Trautschold).

Holotype. Museum of Earth Science of Moscow State University, no. 116/1; Moscow Region, quarry of Ramenskii Enrichment Factory; Volgian Stage, Upper Substage, *fulgens* Zone, 20 cm above the base of the zone.

Description. The shells are noticeably convex and rounded-triangular. The length of the valves considerably exceeds the width. The external calcite layer is developed over the entire surface of the aptychi, but its thickness is 0.2–0.3 of that of the organic layer (Figs. 3a, 3b). The thickness of the organic layer increased toward the terminal angle. The angle between the harmonic and inner margin is about 100°. The external surface of the calcite and organic layers is covered by weakly pronounced, smoothened ribs and growth lines. The inner side of the aptychi is almost smooth.

Plate 2



Explanation of Plate 2

Figs. 1–5. Aptychi *Praestriaptychus fulgens* sp. nov. in the body chambers of the ammonites *Kachpurites fulgens*: (1) holotype no. 116/1; (2) specimen no. 116/4, fragments of the aptychi found in association with an ammonite upper jaw; (3) specimen no. 116/3, aptychi with a well preserved external layer; (4) specimen no. 116/2, a complete lower jaw composed of two connected aptychi; (5) specimen no. 116/5, an aptychus in the body chamber of the macroconch of *K. fulgens*. The scale bar is 1 cm.

Dimensions in mm, ratios, and angles in degrees:

Specimen no.	Dm	Dm_1	WW	Dm_1/Dm	WW/Dm	A	T
116/1	11.7	13	5.5	1.11	0.47	100	72
116/2	9	10	5	1.11	0.55	100	72
116/4	7	7	4	1	0.57	107	–
116/5	15	16.5	10	1.10	0.67	103	78

Variability. The aptychi studied are distinguished in size, relation of the width and length of the valves and the intensity of the ribbing. Judging from the result of the ammonite shell measurements containing aptychi, the length and width of the valves depend on the ammonite size, and from parameters (height and width) of the apertural part of the body chamber. The degree of ribbing in aptychi appears to be an individual character, although ribs and growth lines are generally poorly developed on the surface of these aptychi.

Comparison. The length of the aptychi under description noticeably exceeds their width. This makes them similar to the Lower Callovian *P. koenigi* (Rogov and Gulyaev, 2003), but the latter have much more pronounced ribbing. Apparently, the similar shape of the aptychi can be explained by the similar shell shape and similar body chamber cross-section in *Proplanulites* and *Kachpurites*. The species described is similar to the Middle Volgian *Praestriaptychus volgensis* (Rogov, 2004b) in the proportions of layer thicknesses: the calcite layer is considerably thinner than the organic layer. However, the new species differs from *P. volgensis* in the valve shape. The external margin of *P. fulgens* is not parallel to the harmonic margin, and the terminal angle is more acute. The species described is similar in valve shape to the aptychus found in association with the ammonites *Pavlovia* (Oates, 1974), but differs from that in the much weaker ribbing. The new species is distinguished from the geochronologically older Late Callovian *Praestriaptychus anglicus* and *P. ryasanensis* (Rogov, 2004à) by the almost entirely smooth inner side. It has a thinner calcite layer compared to *P. anglicus* and has the straight harmonic margin in contrast to *P. anglicus*. The smoothened ribbing in the new species is similar to that in the aptychi of the Late Bathonian *Kepplerites* (Mitta, 2009), although these aptychi are distinguished by the more acute apical angle.

Remarks. The external calcite layer of the aptychi under description is very thin; hence it is very easily destroyed. Therefore it is possible that under certain conditions, only the inner lamella of the aptychi will be preserved. Only *Craspedites* shells are found in association with *Kachpurites* in the *fulgens* Zone in the Russian Platform. Unfortunately no confirmed occurrences of aptychi in their body chambers are known. It is possible that an aptychus found in the *fulgens* Zone of the Samara Region (section Kashpir) also belongs to this species (Rogov and Mikhailova, 2006, pl. 1, fig. 3). However, its affinity to the genus *Craspedites* cannot so far be excluded.

Material. Five specimens (two isolated valves of aptychi and three lower jaws) and three lower jaws in various states of preservation from the Upper Volgian *Kachpurites fulgens* Zone of Moscow and the Moscow Region.

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